Mortar Testing

Who? What? Where? When? and Why?

By Richard Filloramo

There are already hundreds of articles, technical publications and reports in circulation regarding mortar testing! Some of these articles date back to 1992. There has been so much confusion regarding mortar specifications, mortar testing and field mortar testing that ASTM published a special standard to address this. So, why another article on mortar testing? This article focuses on economical options for mortar testing and field quality assurance, and emphasizes that compressive strength testing of mortar produced at the job site is not always required and may not be the best method of quality assurance.

Who?

Who should be testing mortar? A good place to start! Mortar testing and other masonry testing procedures should only be performed by an accredited testing agency and laboratory conforming to the *Standard Practice for the Accreditation of Testing Agencies for Unit Masonry* (ASTM C 1093). Some specifications also list ASTM E 548 *Standard Guide for General Criteria Used for Evaluating Laboratory Competence*. This ASTM standard should not be referenced, as it has been withdrawn.

Testing agency employees should be familiar with masonry construction and related ASTM testing standards, and should have field and laboratory experience. Owners and engineers should require agencies to provide ASTM certification, state licensure and reports verifying that their testing laboratory equipment have been calibrated in accordance with ASTM standards for the applicable mortar or masonry testing. Finally, the engineer should investigate references and previous projects to verify the firm's qualifications. A brief interview with the agency, asking pertinent questions relating to mortar testing, would also be advantageous.

Many, so called "failed compression tests of mortar" have actually not failed. Instead, they can be attributed to improper mortar sampling, storage, transportation, testing and interpretation of test results. These improper or misinterpreted mortar test reports have caused project delays, cost overruns and numerous unnecessary lawsuits.

What?

What ASTM mortar test should be performed (if any)? Mortar can be specified in one of two ways (*not both*): by proportion or by property. The *proportion method* allows the contractor to follow the guidelines set forth in Table 1 of ASTM C270 (*Figure 1*). If the materials meet the specifications, mortar testing is not required, because experience has shown these mix designs will produce mortar with the required performance characteristic for the masonry to perform. The *property specification* option allows the contractor to create a specific mix design to achieve the property requirements in Table 2 of ASTM (*Figure 2*). This approach requires a laboratory test of the mortar.

There has been so much confusion regarding mortar specifications, mortar testing and field mortar testing that ASTM published ASTM C 1586 *Standard Guide for Quality Assurance of Mortars*. "This document provides guidance regarding the proper use of Specification C 270 and Test Method C 780 for evaluating masonry mortars produced in a laboratory and at the construction site" (ASTM C 1586-05, Section 1.1 Scope). It is important to review this document and *The Road Map to Quality Mortar: ASTM C 1586* by the Portland Cement Association (see Sidebar on page 3). This publication actually explains ASTM C 1586 and illustrates how to use C 270 and C 780.

Table 1: Proportion Specification Requirements
Note: Two air-entraining materials shall not be combined in mortar.

Proportions by Volume (Cementitious Materials)										
Mortar	Type	Portland Cement or Blended Cement	Mortar Cement			Masonry Cement			Hydrated Lime or Lime Putty	Aggregate Ratio (Measured in Damp, Loose Conditions)
			M	S	N	M	S	N		
Cement-Lime	M S N O	1 1 1 1	... ...	... ...	... ...	... ...	... ...	... ...	¼ over ¼ to ½ over ½ to 1¼ over 1¼ to 2½	
Mortar Cement	M M S S N O	1 ... ½	... 1	... ... 1	1 ... 1 ... 1 1	... ...	... ...	... ...	... ...	Not less than 2¼ and not more than 3 times the sum of the separate volumes of cementitious materials
Masonry Cement	M M S S N O	1 ... ½	... ...	... ...	... ...	... 1	... ... 1	1 ... 1 ... 1 1	... ...	

Figure 1

Table 2: Property Specification Requirements[A]

Mortar	Type	Average Compressive Strength at 28 days, min, psi (MPa)	Water Retention, min, %	Air Content, max, %[B]	Aggregate Ratio (Measured in Damp, Loose Conditions)
Cement-Lime	M	2500 (17.2)	75	12	
	S	1800 (12.4)	75	12	
	N	750 (5.2)	75	14[C]	
	O	350 (2.4)	75	14[C]	
Mortar Cement	M	2500 (17.2)	75	12	Not less than 2¼ and not more than 3 ½ the sum of the separate volumes of cementitious materials
	S	1800 (12.4)	75	12	
	N	750 (5.2)	75	14[C]	
	O	350 (2.4)	75	14[C]	
Masonry Cement	M	2500 (17.2)	75	18	
	S	1800 (12.4)	75	18	
	N	750 (5.2)	75	20[D]	
	O	350 (2.4)	75	20[D]	

[A] Laboratory prepared mortar only (see Note 3).
[B] See Note 4.
[C] When structural reinforcement is incorporated in cement-lime or mortar cement mortar, the maximum air content shall be 12%.
[D] When structural reinforcement is incorporated in masonry cement mortar, the maximum air content shall be 18%.

Figure 2

You now have enough information to continue. What's the point? **Mortar that has been field tested is not required to meet the property specification requirements of ASTM C 270**. For example, if Type S mortar samples (cubes or cylinders) are taken in the field and then tested with a resulting strength of 1350 psi, the mortar does not fail, and thus, it cannot be rejected because it did not reach ASTM C 270 laboratory test strength of 1800 psi. Understood? Then don't stop the job if field tested mortar breaks are lower than those published in ASTM C 270 Table 2. Here is a summary:

Mortar properties that are tested per the property specification requirements of ASTM C 270 must conform to Section 5.3, a test of laboratory prepared mortar. ASTM C 270 Section 3.1 states: *Specification C 270 is not a specification to determine mortar strengths through field testing*.

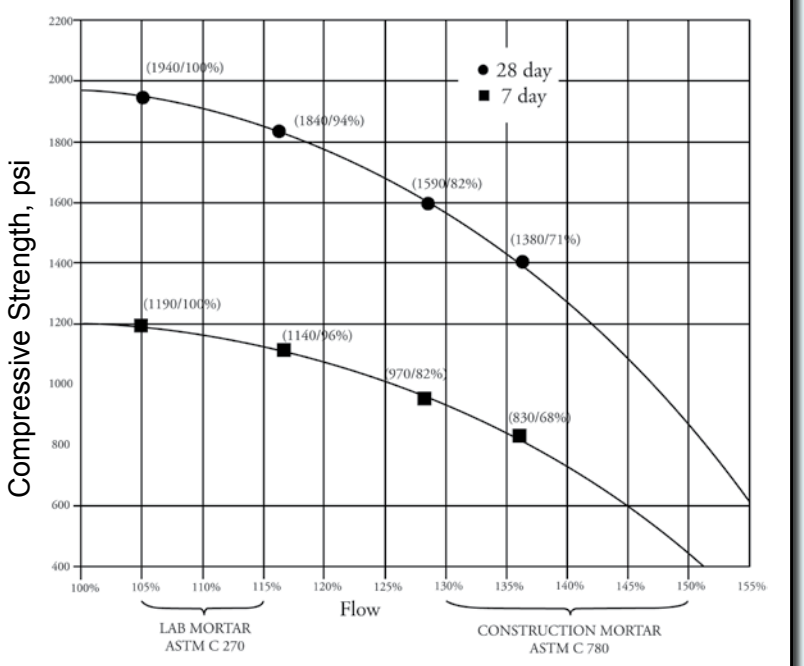
ASTM C 270, Section 3.3 states: *The compressive strength values resulting from field tested mortars do not represent the compressive strength of the mortar as tested in neither the laboratory nor that of the mortar in the wall. Physical properties of field sampled mortar shall not be used to determine compliance to this specification and are not intended as criteria to determine the acceptance or rejection of the mortar (see Section 8)*.

ASTM C 270, Section 8.2 states: *Test method C780 is suitable for the evaluation of masonry mortars in the field. However, due to the procedural differences between specification C 270 and C 780 the compressive strength values resulting from field sampled mortars are not required nor expected to meet the compressive strength requirements of the property specification of C270, nor due they represent the compressive strength of the mortar in the wall.*

ASTM C780, Section 1.4 states: *The test results obtained under this test method are not required to meet the compressive values in accordance with property specifications in C 270*.

ASTM C 1586, Standard Guide for Quality Assurance of Mortars, Section 4.3.2 states: *Do not use specification ASTM C270 Property Specification Requirements to evaluate site produced mortars. Due to the higher amount of water necessary for actual masonry construction, mortar produced and sampled in the field will typically have lower compressive strengths than that produced in the laboratory per Specification C 270*. See also ASTM C 1586 –04, Section 4.3.1.

This section deserves additional explanation. Mortar mixed in the field has higher water content than that produced in the lab. This higher water content is necessary to make the mortar flowable and plastic enough to be used to install masonry units. Some of this water is absorbed or evaporates because of changes in temperature and the time that elapses between mixing and actual use. The remaining water is absorbed into the masonry units. The ASTM C 270 lab test simulates these results by testing mortar with a flow (see ASTM C270, X1.5.3) between 105% and 115%. This is quite different than mortar tested in the field, which has a flow of 130% to 150%. A Flow-Strength Relationship (*Figure 3*) was developed by testing at Cemstone Laboratories in 1999.



*All test specimens 2"x 4" cylinders. When cube and cylinder test specimens from like mixtures are to be compared, the cylinder compressive strength may be considered to be equal to 85% of the cube compressive strength.

Figure 3

Strength Test Method Comparisons For Mortar Mortar Type S - 1800 PSI @ 28 Days All strength tests are from the same mix design				
Specifications	ASTM C 270	ASTM C 780	ASTM C 780	UBC 21-16
Location of Test	Lab	Field	Field	Field
7 Days, PSI	1990	1350	1150	1760
28 Days, PSI	2510	1660	1410	2090
Explanation of Test Differences	2" x 2" Cubes in Lab	2" x 2" Cubes in Field	3" x 6" Cylinders in Field	Spread on Block for 1 Minute
The above tests were conducted and reported by a cement company.				

Figure 4

Figure 4 illustrates another comparison of mortar compression test results based on the type and location of tests.

By now you get the point, and it may be a good time to read ASTM C 270 *Mortar Specifications for Mortar for Unit Masonry* and ASTM C 780 *Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry*. ASTM C 109/C 109M *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-In. or [50-mm] Cube Specimens* can also be reviewed.

There have been hundreds of industry articles informing engineers that field-tested mortar is not required to meet ASTM C 270 strengths, yet incorrect testing procedures continue to cause problems. Engineers may be liable for project delays and associated cost if projects are delayed because of inaccurate interpretation of mortar testing.

Real Solutions

Section 1.2.2 c of the MSJC (ACI 530-02 /ASCE 5-02/TMS 402-02) requires that the compressive strength of masonry used in the design of the masonry walls be shown on the drawings. This usually appears on the notes page of the structural drawings. Architects should also include this information in the specification and carefully coordinate with the engineer. It should be noted that the compressive strength requirement is not necessary in certain parts of the code.

The compressive strength of masonry may be determined by prism testing or unit strength method, as indicated in Section 1.4 of the MSJC (ACI 530.1-02/ASCE 6-02/TMS 602-02) (*Figure 5*). Masonry veneers are exempt from this requirement as noted in MSJC Code 6.1.1.3. Most projects with CMU backup, masonry partitions

The Road Map to Quality Mortar: ASTM C 1586

From PCA Masonry Today, Vol 15, No. 2

In 2004, American Society for Testing and Materials published a new document to help designers, specifiers, inspectors, testing agencies, producers, and users in specifying and evaluating masonry mortar. Designated C 1586, the *Standard Guide for Quality Assurance of Mortars*, it is a road map of how to use specification C 270 and test method C 780, two of the primary ASTM documents on mortar. The Guide seeks to promote the proper use and interpretation of C 270 and C 780, noting that they are often confused and sometimes inadvertently misused.

C 1586 clarifies that qualifications of mortar as meeting C 270 requirements and verification of site proportioning should be viewed as two distinct paths. Both are necessary and they may require similar activities, but their purposes are different. C 270 establishes requirements for materials and mortar mix designs (proportions) and C 780 provides methods to evaluate consistency of site proportioning. Used together, the three documents are meant to take us from concept (design) to a finished structure.

Specifying Mortar: Proportions or Properties

In the United States, mortar can be specified (by C 270) in one of two ways: by proportions or by properties. Proportions allow people to choose a recipe without any mortar testing as long as each material meets established criteria (specifications). Properties allow people a little more discretion in determining the mortar mix design, but this approach necessitates that (lab) tests be run on the mortar. Then that mix design is converted to (volumetric) proportions for use in field mixing.

There is confidence in the proportioning method because experience has shown that if we follow a recipe spelled out in Table 1 of ASTM C 270, we can consistently obtain a mortar that has certain performance characteristics. Then the mortar in the finished wall, and hence, the wall, will perform as intended.

An alternate method of specifying a mortar is to use Table 2, the property table, which sets criteria for mortar. Sample mortar mixes are tested for: minimum average compressive strength, minimum water retention, and maximum air content. The property specification provides a means of qualifying mortars for use when sand does not meet gradation requirements of C 144 and permits a slightly higher sand content than the proportion method.

Evaluating Mortar

C 780 is a collection of mortar tests for both fresh and hardened properties. It can be used to establish the characteristics of mortar before construction begins. Perhaps more importantly, C 780 is used during construction to assess whether the mortar is proportioned as intended.

C 1586 adds a caution regarding test results: the properties and the mortars in C 270 Table 2 are established based on laboratory values, not field values. However, once those properties are established for (lab) mortar, there is a temptation to determine compressive strengths (C 780 testing) and compare directly to the lab values, because the mortar *appears* to be the same mortar. That should not be done because the water content, mixing, placement of the mortar in contact with masonry units, and environment all affect the mortar characteristics. Instead, C 1586 recommends that mortar quality be verified by either inspection (visual observation) or testing (preferably mortar aggregate ratio and water content) or both inspection and testing.

The value of C 1586 is that it helps to clarify the proper use of C 270 and C 780. It reinforces the fact that C 270 leads to a mix design (proportions) for mortar. It further clarifies that C 270 is a test document for lab mortars and that C 780 is for determining properties of field mortars, helpful in a quality assurance program.▪

and shear walls can use the unit strength method for determination of compressive strength. *Figure 6* illustrates Table 2 from the MSJC Specification. The highlighted line indicates that if the concrete masonry units meet the requirements of ASTM C 90, are a minimum of 1900 psi and Type S or M mortar is used, the resulting compressive strength should be 1500 psi. For many projects, this 1500 psi requirement satisfies most designs. Projects that require higher compressive strengths (multi-story load bearing projects or projects with extensive shear walls) sometimes use the prism test option, as it permits the contractor to use lower strength CMU and still accomplish the required compressive strengths. This can sometimes result in a cost savings for the project. However, prism testing is expensive and is subject to more preparation, storing and testing errors. Preconstruction prisms can be used to determine the required unit strengths and any unit tests that should be performed during construction.

A specification and structural note for Unit Strength Method might read:

Design of masonry $f'm$ = 1500 psi.
Provide concrete masonry units in accordance with ASTM C90, 1900 psi.
Units must be sampled and tested in accordance with ASTM C140.
Provide Type S mortar per proportion specification ASTM C 270.

That's it – it's that simple. You do not need prism strength requirements.

The quality assurance requirements are determined by code and building type and may be level 1, 2 or 3, as indicated in *Figure 8*. Even at level 3, prism and mortar testing *is not required*. The unit strength method is still acceptable, and the quality assurance program only requires verification of proportions of site-mixed mortars.

First, if the project requires, perform preconstruction testing using the standard ASTM C 270 laboratory test of mortar whether the mortar is specified as proportion or property.

Verification of site produced mortar can be achieved by using ASTM C 780. Here are some options:

Option One

One method is to simply make visual observations to verify that mortar proportions are correct. This can be accomplished on the job site by measuring sand in a one cubic foot box. Count about how many shovels it takes to fill the box and apply that information to the mix design. For example: A proportion mix for Type S mortar is 1 part portland cement, ½ part lime and 4½ parts sand (3 times the cement and lime).

The exact volumes of portland cement and lime can be determined by weight. In this mix, the portland cement and lime (the cementitious part of Table 1, ASTM C270) = 1 ½ cubic feet. Therefore, 4 ½ cubic feet of sand is needed for each mix. In this example, it takes about 8 shovels of sand to fill one cubic foot box, so 36 shovels will be needed

1.4.— System description

1.4A *Compressive strength requirements* — Compressive strength of masonry in each masonry wythe and grouted collar joint shall equal or exceed the application f'_m. At the transfer or prestress, the compressive strength of the masonry shall equal f'_{mi}, which shall be lass than or equal to f'_m.

1.4B *Compressive strength determination*

1. *Alternatives for determination of compressive strength* — determine the compressive strength method or by the prism test method as specified herein.
2. *Unit strength method*
   a. *Clay masonry* — Determine the compressive strength of masonry based on the strength of the units and the type of mortar specified using Table 1. The following Articles must be met:
      1) Units conform to ASTM C 62, ASTM C 216, or ASTM C 652 and are sampled and tested in accordance with ASTM C 67.
      2) Thickness of bed joints does not exceed ⅝ inch (15.9 mm).
      3) For grouted masonry, the grout meets one of the following requirements:
         a) Grout conforms to ASTM C 476.
         b) Grout compressive strength equals f'_m but compressive strength is not less than 2000 psi (13.79 MPa). Determine compressive strength of grout in accordance with ASTM C 1019.

   b) *Concrete masonry* — Determine the compressive strength of masonry based on the strength of the unit and type of mortar specified using Table 2. The following Articles must be met:
      1) Unit conform to ASTM C 55 or ASTM C 90 and are sampled and tested in accordance with ASTM C 140.
      2) Thickness of bed joints does not exceed ⅝ inch (15.9 mm).
      3) For grouted masonry, the grout meets one of the following requirements:
         a) Grout conforms to ASTM C 476.
         b) Grout compressive strength equals f'_m but compressive strength is not less than 2000 psi (13.79 MPa). Determine compressive strength of grout in accordance with ASTM C 1019.
3. *Prism Test Method* — Determine the compressive strength of masonry by the prism test method in accordance with ASTM C 1314.

1.4C *Adhered veneer requirements* — Determine the adhesion of adhered veneer unit to backing in accordance with ASTM C 482

Figure 5

Table 2: Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction

Net area compressive strength of concrete masonry units, psi (MPa)		Net area of compressive strength of masonry, psi (MPa)
Type M or S mortar	Type N mortar	
1250 (8.62)	1300 (8.96)	1000 (6.90)
1900 (13.10)	2150 (14.82)	1500 (10.34)
2800 (19.31)	3050 (21.03)	2000 (13.79)
3750 (25.86)	4050 (27.92)	2500 (17.24)
4800 (33.10)	5250 (36.20)	3000 (20.69)

[1]For units of less than 4 in. (102 mm) height, 85 percent of the values listed.

Figure 6

to make this batch of mortar on the site. Since the volume of sand can range from 2 ¼ to 3 times the cementitious volume, variations are permissible. Cement and lime come pre-bagged, providing for more consistent volumes.

Option Two

Pre-mixed bag mortar (80 lbs) and pre-mixed bulk mortar in large bags (3000 lb) are very commonly used on construction projects. Since the cement, lime and sand or other ingredients are mixed at the factory, field verification of proportions is not possible. The mortar can be taken dry to the testing agency and tested in accordance to ASTM C 270.

Option Three

Another method to verify proportions is the mortar aggregate ratio from ASTM C 780, Annex A4/A5. This test compares the volume of sand to the cementitious materials in fresh mortar. Alcohol is used to retard hydration, and a sieve analysis determines the volume of aggregates. This test can be performed in a few hours as compared to the seven or twenty eight days required for compression testing. Some industry groups are recommending this procedure, yet a poll of industry testing labs has shown that this test is not performed that often, and that results can vary based on inconsistencies in testing procedures. See Masonry Construction Magazine, October 2004, *Mortar Testing for Quality Assurance* for more information. Currently, ASTM C12.02.01 which oversees the C 780 document is addressing the mortar aggregate ratio test method and ways to improve it to arrive at more consistent results.

Option Four

ASTM C 270 preconstruction testing of mortar can be performed using the project mortar mix ingredients from the job site and tested in a laboratory with water cement ratios meant to simulate both freshly mixed field mortar and in place mortar strengths. *Figures 7A* and *7B* show an example of such a preconstruction test report. In this example, the simulated field mixed mortar (140% flow) tested 550 psi lower than the simulated in place mortar (112% flow). This information can now be used for comparison to ASTM C 780 compression test of field sampled mortar. However, variations should still be expected, as indicated in the notes section of the report.

Preconstruction strength testing of field mortar can be performed to establish a baseline for testing during construction. However, it is important to remember, that variations are expected. For example, a project requires Type S mortar per property specification to attain 1800 psi. Prior to construction, several 2- x 2-inch cube samples of field produced mortar with varying amounts of water are compression tested with results averaging about 1300 psi. Therefore, similar results can be expected during construction and may range from 1000 to 1600 psi. *Figure 3* indicates a similar range when job site mortar flow ranges from 130% to 150%.

Project: Spec Mix
Project: Quality Control
Subject: **Evaluation of Mortar**

I) Material: Spec mix premixed mortar (sample reference #103)
Sampled by: Client
Date Cast: 06-20-03
A) ASTM C-270-laboratory mix – flow 110 ± 5%.
Flow rate: 112 % Simulates in place mortar

Sample No	Test Age, Days	Date Tested	Load, LBS.	Compressive Strength, PSI
S-64573	7	06-27-03	7800	1950
S-64574	7	06-27-03	7100	1780
S-64575	7	06-27-03	7400	1850
S-64576	28	07-18-03	10,000	2500
S-64577	28	07-18-03	9500	2380
S-64578	28	07-18-03	9800	2450
			Average 28 day compressive strength	2440

II) Material: Spec mix premixed mortar (sample reference #103)
Sampled by: Client
Date Cast: 06-20-03
A) ASTM C-270 - laboratory mix - flow 130-140%.
Flow rate: 140% Simulates freshly mixed mortar

Sample No	Test Age, Days	Date Tested	Load, LBS.	Compressive Strength, PSI
S-64635	7	06-30-03	6000	1500
S-64636	7	06-30-03	6600	1650
S-64637	7	06-30-03	5800	1450
S-64638	28	07-21-03	7300	1830
S-64639	28	07-21-03	7500	1880
S-64640	28	07-21-03	7800	1950
			Average 28 day compressive strength	1890

III) Correction factor to apply to 28 day field compressive strength tests: +550 PSI

NOTES

A) It is noted that the ASTM C-780 mixes contained herein approximate the mix consistency as batched in the field. The ASTM C-270 mixes contained herein are intended to duplicate the in-place mortar. The in-place mortar (and the field tested mortar) compressive strength property, may still vary considerably from these mixes, due to the following:
1) Project masonry units will absorb water from the mix to various degrees depending on moisture content and absorption of the particular units used.
2) Mix ingredients, ambient temperatures (even when within specification limits) and climatic conditions.
3) Per ASTM C-270, mortar may be re-tempered by adding water as frequently needed to restore the required consistency (work ability and bond are generally considered more important mortar characteristics than compressive strength).
4) Time elapsed from mixing (specification limit 2½ hours)
5) Other masonry properties (air content, water retentivity, stiffening characteristics, etc.) may also effect compressive strength.
6) The ultimate compressive strength of typical ⅜" bed joint will probably be well over twice the value obtained when the mortar is tested using a 2" cube (ASTM D-270 appendix X1.6.3.2)

Figure 7A

MATERIALS TESTING, INC.

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871 STAFFORD ROAD • EAGLEVILLE, CONNECTICUT 06268 • (860)487-1972

NVLAP #0320
Specific Scope Accredited

DATE: 07-21-03

REPORT: S-1178

CLIENT: Spec Mix
Division of Package Pavement Co., Inc.
675 Leetown Road
Stormville, NY 12582

PROJECT: Quality Control

SUBJECT: **Preconstruction Testing and Evaluation of Mortar**

STATE OF CONNECTICUT ESMAT MIKAEL ALI NO. 21956 PROFESSIONAL ENGINEER

Preconstruction testing of mortar was performed using production line ingredients, sampled by the client. The compressive strength properties of laboratory prepared mortar, were evaluated with water cement ratios meant to simulate both freshly mixed mortar and in place mortar strengths. As ACI/ASTM does not recognize field testing of mortar for compressive strength, the comparison gives Engineering a tool for evaluating field compressive strength test. In place compressive strengths may now be estimated based on fresh mortar compressive strength and this report.

A flow table meeting the requirements of ASTM C-230, was used to determine the consistency of mortar trial batches until proper flow rates simulating field conditions were achieved. (As indicated in ASTM C-109 10.3.3). Flow of mortar was determined in accordance with ASTM C-270 appendix X1.5.3 and ASTM C-109 section 10.3. Mixing of all mortar batches was in accordance with ASTM C-305. Tow inch (2") cube specimens were fabricated and tested for compressive strength in accordance with ASTM C-109 and ASTM C-780. Six (6) specimens were cast for each mixture to show seven (7) and twenty-eight (28) day results.

Figure 7B

Where?

Where should mortar be tested? The "where" in this question pertains to "where on the project", or for which wall, should the mortar be tested. Testing of structural masonry walls generally depends on the building classification, building structure and building code. These structural walls include loadbearing walls, shear walls, exterior back-up walls, exterior single wythe or composite walls, and any walls that are part of the lateral, seismic or wind load resisting system. Partition walls are usually non-structural and do not require mortar testing. Reinforced partition walls, sometimes required in moderate to high seismic areas, may require mortar testing. Buildings in high wind areas may also require more testing.

Figure 8 illustrates the three levels of Quality Assurance from the MSJC 2002. The level is determined by the building code. For example: Masonry loadbearing buildings that are essential structures require a Level 3 Quality Assurance. Notice, that even in level 3, only the proportions of site-mixed mortar are required.

Masonry veneers (brick, CMU, stone) are non-structural components and generally do not require mortar testing. However, industry standards generally recommend Type N mortar for veneers. This mortar is weaker (750 psi) than Type S (1800 psi) and Type M (2500 psi) and contains more lime (less cement). This makes it more flexible and reduces cracking in the veneer. The higher lime content allows more healing of minor cracks. Therefore, it may be beneficial to periodically test veneer mortars to make sure they are not too strong (containing too much cement). If field testing of mortar is performed, then a preconstruction benchmark test must be performed as described above.

When?

When should mortar be tested? Mortar should be tested prior to the start of masonry construction and simultaneously with submittals. The frequency of testing will vary with building type and codes. Level 3 Quality Assurance indicates testing every 5000 SF. (*Figure 8*)

Why?

Why should mortar be tested? Good question. As you can now see, mortar testing is not required most of the time. As previously explained, if proportion specification is used, simple observation is all that is required. Mortar testing results can and will vary due to testing variations. Since each project will vary, a plan should be established for each project prior to construction.

Moving Forward

- The best plan is to understand mortar testing. Make sure the owner, architect, engineer, CM, mason contractor, testing agency and all involved parties understand mortar testing. Read and circulate this article and references.
- Establish a specific mortar and masonry testing plan for the project.
- Perform preconstruction mortar testing well in advance of construction, especially when using the results for testing field-mixed mortar.
- Investigate the testing laboratory's credentials.
- The engineer or a neutral party should be engaged to periodically oversee testing procedures, especially on large projects with structural masonry. Make sure mortar samples are made, stored and transported correctly. Inspect an occasional test in the laboratory.
- Perform occasional side-by-side mortar and other masonry tests using two different testing agencies and compare the results. Do this during preconstruction also. If this requirement is not in the specifications, the mason contractor should include it in his bid and perform this side-by-side testing.
- Always consider that low mortar breaks may be attributed to testing and environmental variations.▪

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Table 3 – Level 1 Quality Assurance	
MINIMUM TESTS AND SUBMITTALS	MINIMUM INSPECTION
Certificates for materials used in masonry construction indicating compliance with the contract documents	Verify compliance with the approved submittals
Table 4 – Level 2 Quality Assurance	
MINIMUM TESTS AND SUBMITTALS	MINIMUM INSPECTION
Certificates for materials used in masonry construction indicating compliance with the Contract Documents Verification of f'_m in accordance with Article 1.4 B prior to construction, except where specifically exempted by this Code	As masonry construction begins, verify the following are in compliance: • proportions of site-prepared mortar • construction of mortar joints • location of reinforcement, connectors, and prestressing tendons and anchorages • prestressing technique Prior to grouting, verify the following are in compliance: • grout space • grade and size of reinforcement, and prestressing tendons and anchorages • placement of reinforcement, connectors and prestressing tendons and anchorages • proportions of site-prepared grout and prestressing grout for bonded tendons • construction of mortar joints Verify that the placement of grout and prestressing grout for bonded tendons is in compliance Observe preparation of grout specimens, mortar specimens, and/or prisms Verify compliance with the required inspection provisions of the of the contract documents and the approved submittals
Table 5 – Level 3 Quality Assurance	
MINIMUM TESTS AND SUBMITTALS	MINIMUM INSPECTION
Certificates for materials used in masonry construction indicating compliance with the Contract Documents Verification of f'_m in accordance with Article 1.4 B: • prior to construction • every 5000 sq. ft. (464.5m^2) during construction Verification of proportions of materials in mortar and grout as delivered to the site	From the beginning of masonry construction and continuously during construction of masonry, verify the following are in compliance: • proportions of site-mixed mortar, grout, and prestressing grout for bonded tendons • grade and size of reinforcement, and prestressing tendons and anchorages • placement of masonry units and construction of mortar joints • placement of reinforcement, connectors and prestressing tendons and anchorages • grout space prior to grouting • placement of grout and prestressing grout for bonded tendons Observe preparation of grout specimens, mortar specimens, and/or prisms Verify compliance with the required inspection provisions of the contract documents and the approved submittals

Figure 8

References:

1. ASTM C 1586 *Standard Guide for Quality Assurance of Mortar*
2. ASTM C 1093 *Standard Practice for the Accreditation of Testing Agencies for Unit Masonry*
3. ASTM C 270 *Mortar Specifications for Mortar for Unit Masonry*
4. ASTM C 780 *Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry*
5. ASTM C 109/C 109M *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-In. or [50-mm] Cube Specimens*
6. Spec Mix - Guide to Field Sampling of Mortar for Laboratory Testing
7. Portland Cement Association (PCA) Quality Assurance for Masonry Mortars - Masonry Information 1995
8. International Masonry Institute – Technology Brief Section 2.9.1, June 2004, Mortars For Masonry.
9. National Concrete Masonry Association (NCMA) – NCMA TEK Notes 18-5A and 9-1A
10. Brick Industry Association (BIA) BIA Technical Notes 8, 8A and 8b.
11. Masonry Construction Magazine / November 2000 Passing Grades
12. Masonry Construction Magazine / October 2004 Mortar Testing for Quality Assurance
13. Masonry Standards Joint Committee (MSJC) Building Code Requirements for Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02), Specifications for Masonry Structures (ACI 530.1-02/ASCE 6-02/TMS 602-02) and Commentaries.

Additional Reading and Resources

Spec Mix - Guide to Field Sampling of Mortar for Laboratory Testing
(Contact IMI or Spec-Mix, Inc. for this publication)

Portland Cement Association (PCA) - Quality Assurance for Masonry Mortars - Masonry Information 1995. (**www.cement.org**)

International Masonry Institute – Technology Brief Section 2.9.1, June 2004, Mortars For Masonry. Call 1-800-IMI-0988

National Concrete Masonry Association (NCMA) – NCMA TEK 18-5A and 9-1A
(Go to **NCMA.org**, select online services, E Tek.

Brick Industry Association (BIA) BIA Technical Notes 8, 8A and 8B.
(Go to **BIA.org**, select Technical Notes.

Masonry Construction Magazine / November 2000 Passing Grades
(**www.masonryconstruction.com**)

Masonry Construction Magazine / October 2004 Mortar Testing for Quality Assurance
(**www.masonryconstruction.com**)

Masonry Construction Magazine / April 2005 Specifying or Inspecting Masonry Mortar (**www.masonryconstruction.com**)